

ACEP Policy Statement

Emergency Ultrasound Imaging Criteria Compendium

Approved by ACEP
Board of Directors
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This compendium contains the following criteria:

- Aorta
- Biliary
- Echocardiography
- Pelvic Ultrasound
- Renal
- Trauma
- Ultrasound-Guided Procedures
- Venous Thrombosis

Aorta

1. Introduction

The American College of Emergency Physicians (ACEP) has developed these criteria to assist practitioners performing emergency ultrasound studies (EUS) of the abdomen and retroperitoneum in patients suspected of having an acute abdominal aortic aneurysm (AAA).

Ultrasound has been shown to be accurate in identifying both aneurysmal and normal abdominal aortas. In most cases, EUS is used to identify or exclude the presence of infrarenal AAA. In some cases, EUS of the abdominal aorta can also identify the presence of suprarenal AAA or of distal dissection. If thoracic aortic aneurysm or proximal dissection is suspected, these may be detected using transthoracic techniques or may require additional diagnostic modalities. Patients in whom AAA is identified also need to be assessed for free intraperitoneal fluid.

EUS evaluation of the aorta occurs in conjunction with other EUS applications and other imaging and laboratory tests. It is a clinically focused examination, which, in conjunction with historical and laboratory information, provides additional data for decision-making. It attempts to answer specific questions about a particular patient's condition. While other tests may provide information that is more detailed than EUS, have greater anatomic specificity, or identifies alternative diagnoses, EUS is non-invasive, is rapidly deployed and does not entail removal of the patient from the resuscitation area. Further, EUS avoids the delays, costs, specialized technical personnel, the administration of contrast agents and the biohazardous

potential of radiation. . These advantages make EUS a valuable addition to available diagnostic resources in the care of patients with time-sensitive or emergency conditions such as acute AAA.

2. Indications/Limitations

a. Primary

- i. The rapid evaluation of the abdominal aorta from the diaphragmatic hiatus to the aortic bifurcation for evidence of aneurysm.

b. Extended

- i. Abdominal aortic dissection
- ii. Thoracic aortic dissection
- iii. Intraperitoneal free fluid in the event that AAA is identified
- iv. Iliac artery aneurysms

c. Contraindications

- i. There are no absolute contraindications to abdominal aorta EUS. There may be relative contraindications based on specific features of the patient's clinical situation.

d. Limitations

- i. EUS of the aorta is a single component of the overall and ongoing resuscitation. Since it is a focused examination EUS does not identify all abnormalities or diseases of the aorta. EUS, like other tests, does not replace clinical judgment and should be interpreted in the context of the entire clinical picture. If the findings of the EUS are equivocal additional diagnostic testing may be indicated.
- ii. Examination of the aorta may be technically limited by
 1. Obese habitus
 2. Bowel gas
 3. Abdominal tenderness

e. Pitfalls

- i. When bowel gas or other technical factors prevent a complete systematic real-time scan through all tissue planes, these limitations should be identified and documented. Such limitations may mandate further evaluation by alternative methods, as clinically indicated.
- ii. A small aneurysm does not preclude rupture. A patient with symptoms consistent with acute AAA and an aortic diameter greater than 3.0 cm should have this diagnosis (or alternative vascular catastrophes) ruled out.
- iii. The absence of free intraperitoneal fluid does not rule out acute AAA as most acute AAAs presenting to the ED do not have free peritoneal fluid.
- iv. The presence of retroperitoneal hemorrhage cannot be reliably identified by EUS.
- v. If an AAA is identified, it still may not be the cause of a patient's symptoms.
- vi. While most aneurysms are fusiform, extending over several centimeters of aorta, saccular aneurysms are confined to a short focal section of the aorta, making them easily overlooked. This may be avoided by methodical, systematic real-time scanning through all tissue planes.
- vii. Oblique or angled cuts exaggerate the true aortic diameter. Scanning planes should be obtained that are either exactly aligned with, or at exact right angles to, the main axis of the vessel.
- viii. With a tortuous or ectatic aorta "longitudinal" and "transverse" views should be obtained with respect to the axis of the vessel in order to avoid artifactual exaggeration of the aortic diameter.
- ix. Large para-aortic nodes may be confused with the aorta and/or AAA. They usually occur anterior to the aorta, but may be posterior, displacing

the aorta away from the vertebral body. They can be distinguished by an irregular nodular shape, identifiable in real-time. If color flow Doppler is utilized nodes will not demonstrate luminal flow.

3. Qualifications and Responsibilities in the performance and interpretation of EUS of the aorta

EUS of the aorta provides information that is the basis of immediate decisions about further evaluation, management, and therapeutic interventions. Because of its direct bearing on patient care, the rendering of a diagnosis by EUS represents the practice of medicine, and therefore is the responsibility of the supervising physician.

Due to the time-critical and dynamic nature of acute AAA, emergent interventions may be mandated by the diagnostic findings of EUS of the aorta. For this reason, EUS of the aorta should occur as soon as the clinical decision is made that the patient needs a sonographic evaluation.

Physicians of a variety of medical specialties may perform EUS of the aorta. Training should be in accordance with specialty or organization specific guidelines. Physicians should render a diagnostic interpretation in a time frame consistent with the management of acute AAA, as outlined above.

4. Specifications for the performance and interpretation of EUS of the aorta

- a. General – Simultaneously with other aspects of resuscitation, ultrasound images are obtained demonstrating the abdominal aorta from the diaphragmatic hiatus to the bifurcation.
- b. Technique
 - i. Identification. The aorta is most easily identified and most accurately measured in the transverse plane. The transverse

image of the vertebral body is identified. The aorta is a circular structure identified as tubular in real-time adjacent to the left anterior surface of the vertebral body.

ii. Real-time scanning technique.

1. Overview. The abdominal aorta extends from the diaphragmatic hiatus to the bifurcation. The surface anatomy corresponding to these points are the xiphoid process and the umbilicus. If possible, the probe is held at right angles to the skin and slid from the xiphoid process down the abdominal midline to the umbilicus, providing real-time systematic scanning through all planes from the diaphragm to the bifurcation. The probe is then rotated 90 degrees and real-time images are obtained of all longitudinal planes by rocking or sliding the probe from side to side.
2. Details of technique. In the subxiphoid area the liver often provides a sonographic window. A cooperative patient may be asked to take a deep breath, which augments this window by lowering the diaphragm and liver margin. Frequently, gas in the transverse colon obscures the midsection of the aorta in a roughly 5-centimeter band between the xiphoid process and the umbilicus. This precludes a systematic sliding movement of the probe from xiphoid to umbilicus. In order to circumvent the gas filled transverse colon, it is necessary to use a rocking technique in the windows above and below this sonographic obstacle. This may give rise to a

slightly exaggerated measurement of the AP aortic diameter because the scanning plane is not completely at right angles to the tubular axis of the aorta.

However, it is necessary to use this technique since it often allows for real-time systematic scanning through all planes of the organ of interest, and will diminish the possibility of missing a small saccular aneurysm.

After a systematic real-time scan in transverse planes, the aorta should be scanned longitudinally. In this view, abnormalities in the lateral walls may be missed, but focal abnormalities in the anterior or posterior walls and absence of normal tapering are more easily appreciated.

3. Additional windows. If bowel gas and/or truncal obesity interfere with visualization of the aorta in the anterior midline, the emergency physician should use any probe position that affords windows of the aorta. In particular, two additional windows can be used. First, in the right midaxillary line intercostal views using the liver as a window can sometimes provide images of the aorta. To optimize this approach, the patient may be placed in a left decubitus position. On this view the aorta will appear to be lying “deep” to the inferior vena cava. Second, the distal aorta can sometimes be most easily visualized with the probe placed in a left paraumbilical region.

Evaluation of the ascending aorta and aortic arch for dissection or

aneurysm can be performed using parasternal and suprasternal windows. These are discussed in the section on emergency cardiac ultrasound.

4. Measurements. The aorta and iliacs are measured from the outside margin of the wall on one side to the outside margin of the other wall. The maximum aortic diameter should be measured in both transverse and longitudinal planes.

For technical reasons, when scanning in the transverse plane, the anterior and posterior walls are usually more sharply defined than the lateral walls, allowing for more precise measurements in this direction. However, due to the fact that many AAAs have larger side-to-side than AP diameter, measurements are obtained in both directions when possible.

5. Additional technical considerations – If an AAA is identified, evaluation of the peritoneal cavity for free fluid (using the approach of the Focused Assessment by Sonography in Trauma) should be made. If a high clinical index of suspicion persists despite a normal EUS exam of the aorta, an attempt may be made to evaluate the iliacs for aneurysm.
5. Documentation
EUS of the aorta are interpreted by the treating physician as they are performed and are used to guide contemporaneous clinical decisions. Such interpretations should be documented in the medical record as a dictated, hand-written, or templated note. Documentation should include the indication for the procedure, a

description of the organs or structures studied and an interpretation of the findings. Whenever feasible images should be stored as a part of the medical record and done so in accordance with facility policy requirements. Given the often emergent nature of such ultrasound examinations the timely delivery of care should not be delayed by the archiving of ultrasound images.

6. Equipment Specifications

Curvilinear abdominal or phased array ultrasound probes can be utilized. A 2 - 5 MHz multi-frequency transducer is ideal. The lower end of this frequency range may be needed in larger patients, while the higher frequency will give more detail in thin patients. Both portable and cart-based ultrasound machines may be used, depending on the location and setting of the examination.

7. Quality Control and Improvements, Safety, Infection Control and Patient Educations

Policies and procedures related to quality, safety, infection control and patient education should be developed in accordance with specialty or organizational guidelines. Specific institutional guidelines may be developed to correspond with such guidelines.

Biliary

1. Introduction

The American College of Emergency Physicians (ACEP) has developed these criteria to assist practitioners performing emergent ultrasound (EUS) studies of the right upper quadrant (RUQ) in patients suspected of having acute biliary disease.

Abdominal pain is a common presenting complaint in the emergency department. Biliary disease is frequently a consideration among the possible etiologies. In many cases, EUS of the right upper quadrant may be diagnostic for biliary disease, may exclude biliary disease, or may identify alternative

causes of the patient's symptoms. If biliary disease is identified, EUS also guides disposition by helping to distinguish emergent, urgent, and expectant conditions.

EUS of the RUQ occurs as a component of the overall clinical evaluation of a patient with abdominal pain. It is a clinically focused examination, which, in conjunction with historical and laboratory information, provides additional data for decision-making. It attempts to answer specific questions about a particular patient's condition. While other tests may provide information that is more detailed than EUS, have greater anatomic specificity, or identifies alternative diagnoses, EUS is non-invasive, is rapidly deployed and does not entail removal of the patient from the resuscitation area. Further, EUS avoids the delays, costs, specialized technical personnel, the administration of contrast agents and the biohazardous potential of radiation. These advantages make EUS a valuable addition to available diagnostic resources in the care of patients with time-sensitive or emergency conditions such as acute biliary colic or cholecystitis, as well as other causes of abdominal pain.

2. Indications/Limitations

- a. Primary
 - i. Identification of cholelithiasis
- b. Extended
 - i. Cholecystitis
 - ii. Common bile duct abnormalities, including dilatation and choledocholithiasis
 - iii. Liver abnormalities, including tumors, abscesses, intrahepatic cholestasis, pneumobilia, hepatomegaly
 - iv. Portal vein abnormalities
 - v. Abnormalities of the pancreas
 - vi. Other gallbladder (GB) abnormalities, including tumors
 - vii. Unexplained jaundice
 - viii. Ascites

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- c. Contraindications
 - ii. There are no absolute contraindications to RUQ EUS. There may be relative contraindications based on specific features of the patient's clinical situation.
 - d. Limitations
 - i. EUS of the RUQ is a single component of the overall and ongoing evaluation. Since it is a focused examination EUS does not identify all abnormalities or diseases of the RUQ. EUS, like other tests, does not replace clinical judgment and should be interpreted in the context of the entire clinical picture. If the findings of the EUS are equivocal additional diagnostic testing may be indicated.
 - ii. The primary focus of RUQ EUS is to identify or exclude gallstones. Other entities, including hepatic tumors, abnormalities of the pancreas or abnormalities of the portal system would not usually be identified by a limited and focused exam.
 - iii. Examination of the RUQ may be technically limited by
 - 1. Obese habitus
 - 2. Bowel gas
 - 3. Abdominal tenderness
 - e. Pitfalls
 - i. When bowel gas or other technical factors prevent an adequate examination, these limitations should be identified and documented. As usual in emergency practice, such limitations may mandate further evaluation by alternative methods.
 - ii. Failure to identify the GB may occur with chronic cholecystitis particularly when filled with stones. Or, would not be identified in the rare instances of GB agenesis. Failure to identify the GB would warrant additional diagnostic testing.
 - iii. The GB may be confused with other fluid filled structures including the portal vein, the inferior vena cava, and hepatic or renal cysts or even loculated collections of fluid. These can be more accurately identified with careful scanning in multiple planes.
 - iv. Measurement of posterior GB wall thickness may be difficult due to the frequent presence of closely apposed loops of bowel. Measurement of GB wall thickness should be made on the anterior wall, where the GB is adjacent to the hepatic parenchyma.
 - v. Small gallstones may be overlooked or mistaken for gas in an adjacent loop of bowel. In questionable cases, gain settings should be optimized, the area should be scanned from several directions, and the patient should be repositioned to check for the mobility of gallstones.
 - vi. Gas in loops of bowel adjacent to the posterior wall of the GB may be mistaken for stones. The two may be distinguished by optimizing gain to identify shadowing, by the presence of peristalsis in bowel, and by the absence of gravitational effect when the patient is repositioned.
 - vii. Small stones in the GB neck may easily be overlooked or mistaken for lateral cystic shadowing artifact (edge shadows). It may be necessary to image this area from several directions to avoid this pitfall.
 - viii. Common bile duct stones may only be identified by the shadowing they cause.
 - ix. Cholesterol stones are often small, less echogenic, may float, and may demonstrate "comet tailing."
 - x. Pneumobilia and emphysematous cholecystitis are subtle finding and may produce increased echogenicity and comet-tailing caused by gas in the biliary tree and GB wall.

- xi. Polyps may be mistaken for gallstones. The former are non-mobile and do not shadow.
 - xii. GB wall thickening may not represent biliary pathology, but may be physiological, as in the post-prandial state, or with non-surgical conditions such as hypoproteinemia, congestive heart failure.
 - xiii. The presence of gallstones or other findings consistent with cholecystitis does not rule out the presence of other life-threatening causes of epigastric pain such as aortic aneurysm or myocardial infarction.
 - xiv. Except for emergency physicians with extensive experience in EUS, evaluations of the liver, pancreas and Doppler examination of the portal venous system are not part of the normal scope of EUS of the RUQ.
3. Qualifications and Responsibilities of the Performing Medical Professional
Biliary EUS is the basis of immediate decisions concerning further evaluation, management, and therapeutic interventions. Because of its direct bearing on patient care, the rendering of a diagnosis by biliary EUS represents the practice of medicine, and therefore is the responsibility of the supervising physician.

Due to the time-critical and dynamic nature of many causes of abdominal pain and biliary pathology, emergency interventions may be undertaken based upon findings of the EUS exam. For this reason, EUS should occur as soon as the clinical decision is made that the patient needs a sonographic exam. Physicians of a variety of medical specialties may perform biliary ultrasound. Training should be in accordance with specialty or organization specific guidelines. Physicians should render a diagnostic interpretation in a time frame consistent with the management of acute GB disease, as outlined above.
4. Specifications for performance and interpretation of biliary EUS
 - a. General –Organs and structures evaluated in the RUQ are scanned systematically in real time through all tissue planes in at least two orthogonal directions. The primary focus of the biliary EUS examination is the identification of gallstones. Evaluation of the GB for evidence of cholecystitis and examination of the liver and biliary tree, as described in “Extended Indications”, are performed based on the clinical situation and appropriate emergency physician’s sonographic experience.
 - b. Technique
 - i. Identification
 1. Gallbladder. The normal GB is highly variable in size, shape, axis, and location. It may contain folds and septations, and may lie anywhere between the midline and the midaxillary line. The axis and location of the porta hepatis are also highly variable. Orientation of images of the GB and common bile duct are conventionally defined with respect to their axes as longitudinal, transverse, and oblique, rather than standardized anatomic planes such as sagittal, coronal, oblique and transverse.

In most cases, the GB lies immediately posterior to the inferior margin of the liver in the mid-clavicular line. In some patients, the fundus may extend several centimeters below the costal margin; in others, the GB may be high in the hilum of the liver, almost completely surrounded by hepatic parenchyma. In order to avoid confusing it with fluid-filled

tubular structures, the entire extent of the GB is scanned in real time in its long and short axes.

2. Common bile duct. It is usually located by identifying the portal vein in the porta hepatis, which it reliably accompanies.
- ii. Real-time scanning technique
 1. Overview: A general-purpose curved array abdominal probe with a frequency range of between 2-5 MHz is generally used. A small footprint or phased array probe may facilitate scanning between the ribs. As with other EUS, the organs of interest are scanned methodically in real-time through all tissue planes in at least two orthogonal directions.
 2. In most patients, the inferior margin of the liver provides a sonographic window for the GB below the costal margin. In many cases, this window can be augmented by asking the patient to take and hold a deep breath. It may also be helpful to place the patient in a left decubitus position. The transducer is placed high in the epigastrium with the indicator in a cephalad orientation. The probe is swept laterally while being held immediately adjacent to the costal margin. The liver margin should be maintained within the field of view on the screen.
 3. In patients whose liver margin cannot be visualized below the costal margin, an intercostal approach is necessary. In order to minimize rib shadowing, the transducer is oriented with the plane of the probe parallel to the ribs and the indicator directed toward the vertebral end of the rib. This plane is about 45 degrees counter-clockwise from the long axis of the patient's body. The probe is swept laterally from the sternal border to the midaxillary line until the GB is located.
 4. When the GB has been located, its long and short axes are identified. In the long axis, images are obtained, by convention, with the GB neck on the left of the screen, and the fundus on the right. The GB is scanned systematically in real time through all tissue planes in both long and short axis views. In many patients a combination of subcostal and intercostal windows allows for views of the GB from multiple directions and may help in identifying small stones, resolving artifacts, and examining the gall bladder neck.
 5. The common bile duct is most easily located sonographically by finding and identifying the portal vein, which, with the hepatic artery and CBD, comprise the porta hepatis. Several techniques can be used to locate the CBD in addition to anatomic location. These include tracking the hepatic artery from the celiac axis, tracking the portal vein from the confluence of the splenic and superior mesenteric veins, and following the portal vessels in the liver to the hepatic hilum. In a transverse view of the porta hepatis, the CBD and hepatic artery are typically seen anterior to the portal vein. The CBD is usually more lateral than the hepatic artery or more to the left

on the screen. It can also be distinguished by its absence of a color-flow Doppler signal if this modality is employed.

- iii. Key components of the exam. The GB is systematically scanned as described, with particular attention to the neck. For patients with low hanging GB, the fundus may be obscured by gas-filled colon. Decubitus positioning or exhalation may help provide adequate windows in this situation. The principal abnormal finding is gallstones that are echogenic with distal shadowing. Measurements of the GB wall thickness, if performed, are made on the anterior wall between the lumen and the hepatic parenchyma. Measurements of GB size are rarely helpful in EUS, although gross increases in transverse diameter or overall size may be evidence of cholecystitis and hydrops, respectively. A qualitative assessment of the wall and pericholecystic regions should also be made, looking for mural irregularity, breakdown of the normal trilaminar mural structure, and fluid collections.

The common bile duct, like other tubular structures, is most accurately measured when imaged in a transverse plane. It is most reliable to measure the intraluminal diameter (inside wall to inside wall). Evaluation of the CBD may reveal shadowing suggesting stones and/or comet-tail artifact suggesting pneumobilia. The question of such findings would warrant additional diagnostic testing.

- iv. Pathologic findings
1. Cholelithiasis - Gallstones are often mobile (move with patient positioning) and usually cause

shadowing. Optimization of gain, frequency and focal zone settings may be necessary to identify small gallstones and to differentiate their shadows from those of adjacent bowel gas.

2. Cholecystitis - This diagnosis is based on the entire clinical picture in addition to the findings of the EUS. The following sonographic findings support the diagnosis of cholecystitis.
- a. Thickened, irregular, or heterogeneously echogenic GB wall is measured along the anterior surface. Thickness greater than 3 millimeters is considered abnormal.
 - b. Pericholecystic fluid may appear as hypo- or an-echoic regions seen along the anterior surface of the GB within the hepatic parenchyma and suggests acute cholecystitis.
 - c. A Sonographic Murphy's sign is tenderness reproducing the patient's abdominal pain elicited by probe compression directly on the gall bladder, combined with the absence of similar tenderness when it is compressed elsewhere.
 - d. Increased transverse GB diameter greater than 5 cm may be evidence of cholecystitis.
3. Common bile duct dilatation - The normal upper limit of CBD diameter has been described as 3 mm, although several studies have demonstrated increasing diameter with aging in patients without evidence of biliary disease. For this reason, many authorities consider that the normal CBD may increase by 1 mm for every

decade of age.

4. Pathologic findings of the liver and other structures are beyond the scope of the EUS.
5. Documentation
EUS of the RUQ is interpreted by the treating physician as they are performed and are used to guide contemporaneous clinical decisions. Documentation of the RUQ EUS should be incorporated into the medical record as a dictated, hand-written, or templated note. Documentation should include the indication for the procedure, the views obtained, a description of the organs or structures studied and an interpretation of the findings. Whenever feasible, images should be stored as a part of the medical record and in accordance with facility policy requirements. Given the often emergent nature of such ultrasound examinations the timely delivery of care should not be delayed by the archiving of ultrasound images.
6. Equipment specifications
A curvilinear abdominal transducer with frequencies of 2.0-5 MHz is appropriate. A small footprint curved array probe or phased array probe facilitates intercostal scanning. Both portable and cart-based ultrasound machines may be used, depending on the location and setting of the examination.
7. Quality Control and Improvements, Safety, Infection Control and Patient Education
Policies and procedures related to quality, safety, infection control and patient education should be developed in accordance with specialty or organizational guidelines. Specific institutional guidelines may be developed to correspond with such guidelines.

Echocardiography

1. Introduction
The American College of Emergency Physicians (ACEP) has developed these

criteria to assist practitioners performing emergency ultrasound studies (EUS) of the heart in patients suspected of having emergent pericardial or cardiac disease.

The primary applications of cardiac EUS are in the diagnosis or exclusion of pericardial effusion, cardiac tamponade and the evaluation of gross cardiac function. Cardiac EUS is an integral component of patient evaluation and/or resuscitation. It is a clinically focused examination, which, in conjunction with historical and laboratory information, provides additional data for decision-making. It attempts to answer specific questions about a particular patient's condition. Other diagnostic or therapeutic interventions may take precedence or may proceed simultaneously with the cardiac EUS evaluation. While other tests may provide information that is more detailed than EUS, have greater anatomic specificity, or identifies alternative diagnoses, EUS is non-invasive, is rapidly deployed and does not entail removal of the patient from the resuscitation area. Further, EUS avoids the delays, costs, specialized technical personnel, the administration of contrast agents and the biohazardous potential of radiation. These advantages make EUS a valuable addition to available diagnostic resources in the care of patients with time-sensitive or emergency conditions such as acute cardiac disease. In addition cardiac EUS is an integral component of the trauma EUS evaluation.

2. Indications/ Limitations

- a. Primary
 - i. Detection of pericardial effusion and/or tamponade
 - ii. Evaluation of gross cardiac activity in the setting of cardiopulmonary resuscitation
 - iii. Evaluation of global left ventricular systolic function

- b. Extended
 - i. Gross estimation of intravascular volume status and cardiac preload.
 - ii. Identification of acute right ventricular dysfunction and/or acute pulmonary hypertension in the setting of acute and unexplained chest pain, dyspnea, or hemodynamic instability.
 - iii. Identification of proximal aortic dissection or thoracic aortic aneurysm.
 - iv. Procedural guidance of pericardiocentesis, pacemaker wire placement and capture.
- c. Contraindications

There are no absolute contraindications to cardiac EUS. There may be relative contraindications based on specific features of the patient's clinical situation.
- d. Limitations
 - i. Cardiac EUS is a single component of the overall and ongoing evaluation. Since it is a focused examination EUS does not identify all abnormalities or diseases of the heart. EUS, like other tests, does not replace clinical judgment and should be interpreted in the context of the entire clinical picture. If the findings of the EUS are equivocal additional diagnostic testing may be indicated.
 - ii. Assessment of focal wall motion abnormalities is typically outside of the scope of cardiac EUS
 - iii. The evaluation of diastolic dysfunction is typically outside of the scope of cardiac EUS.
 - iv. Analysis of valvular abnormalities and function is typically outside the scope of cardiac EUS.
 - v. While sonographic evidence of a variety of cardiac conditions, including intracardiac thrombus or mass, ventricular aneurysm, septal defects, aortic dissection, myocarditis,
 - vi. hypertrophic cardiomyopathy and valvular vegetations, are occasionally identified on cardiac EUS, these are beyond the scope of the cardiac EUS exam.
- vii. Cardiac EUS is technically limited by:
 1. Abnormalities of the bony thorax
 2. Pulmonary hyperinflation
 3. Massive obesity
 4. The patient's inability to cooperate with the exam
 5. Subcutaneous emphysema
- e. Pitfalls
 - i. When technical factors prevent an adequate examination, these limitations should be identified and documented. As usual in emergency practice, such limitations may mandate further evaluation by alternative methods, as clinically indicated.
 - ii. The measured size of a pericardial effusion should be interpreted in the context of the patient's clinical situation. A small rapidly forming effusion can cause tamponade, while extremely large slowly forming effusions may be tolerated with minimal symptoms.
 - iii. Acute hemopericardium with clotted blood may be isoechoic with the myocardium or hyperechoic, so that it can be overlooked if the examining physician is expecting it to be anechoic as are most effusions.
 - iv. Sonographic evidence of cardiac standstill should be interpreted in the context of the entire clinical picture.
 - v. Cardiac EUS may reveal sonographic evidence of right ventricular strain in cases of massive pulmonary embolus sufficient to cause hemodynamic instability. However, a cardiac EUS may not demonstrate the findings of right ventricular strain and a normal EUS does not exclude pulmonary embolism.
 - vi. Evidence of right ventricular strain may be due to causes other than

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- pulmonary embolus. These include acute right ventricular infarct, pulmonic stenosis, and chronic pulmonary hypertension.
- vii. Small or loculated pericardial effusions may be overlooked. As with other EUS, the heart should be scanned in real-time through multiple tissue planes in two orthogonal directions.
 - viii. Pleural effusions may be mistaken for pericardial fluid. Evaluation of other areas of the chest usually reveals their characteristic shape and location.
 - ix. Occasionally, hypoechoic epicardial fat pads may be mistaken for pericardial fluid. Epicardial fat usually demonstrates some internal echoing is not distributed evenly in the pericardial space.
 - x. The descending aorta may be mistaken for a posterior effusion. This can be resolved by rotating the probe into a transverse plane.
3. Qualifications and Responsibilities of the Performing Medical Professional
Cardiac EUS provides information that is the basis of immediate decisions about further evaluation, management, and therapeutic interventions. Because of its direct bearing on patient care, the rendering of a diagnosis by cardiac EUS represents the practice of medicine, and therefore is the responsibility of the supervising physician.
- Due to the time-critical and dynamic nature of cardiac disease, emergent interventions may be mandated by the diagnostic findings of EUS examination. For this reason, cardiac EUS should be performed as soon as the clinical decision is made that the patient needs a sonographic evaluation.
- Physicians of a variety of medical specialties may perform focused cardiac ultrasound.
- Training should be in accordance with specialty or organization specific guidelines. Physicians should render a diagnostic interpretation in a time frame consistent with the management of acute cardiac disease, as outlined above.
4. Specifications for Individual Examinations
- a. General - Images are obtained and interpreted in real time without removing the patient from the clinical care area. Images are ideally obtained in a left-semi-decubitus position, although the clinical situation often limits the patient to lying supine. Images may be captured for documentation and/or quality review. Recording of moving images, either in video or cine loops, may provide more information than is possible with still cardiac EUS images. However, capturing moving images may be impractical in the course of caring for the acutely ill patient.
 - b. Technique
 - i. Overview
Both patient habitus and underlying pathological conditions affect the accessibility of the heart to sonographic evaluation. For example, patients with causes of pulmonary hyperinflation (e.g. emphysema or intubation) are likely to have poor parasternal windows, while patients with abdominal distension or pain may have an inaccessible subcostal window. For this reason, familiarity in evaluating the heart from a number of cardiac windows and planes increases the likelihood of successful EUS.
 - ii. Orientation
In certain views, cardiologists have traditionally reversed the orientation of the viewing screen. In this orientation, a transverse image of a structure with the probe marker directed to the patient's right would
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show right-sided body structures on the left hand side of the screen. Since reversing the screen for certain images and/or parts of an EUS exam can be time-consuming and confusing, especially under the exigent conditions typical of cardiac EUS, most emergency physicians have adopted the convention of not adjusting the screen orientation in views where the screen is reversed by cardiologists, and have adopted reversing the direction of the probe marker instead. The resulting images appear the same as those in traditional echocardiography texts. Throughout this document, this EUS convention will be followed so that to obtain the views described, the emergency physician will not need to reverse the orientation of the screen. The approximate orientation of the probe marker in the various classic cardiac views is described in terms of a clock face where 12 o'clock is directed to the head, 6 o'clock is directed to the feet, 9 o'clock is directed to the patient's right, and so on.

- iii. The primary cardiac views
Throughout the following discussion "windows" refer to locations that typically afford sonographic access to the heart. Conversely, "views" refer to cardinal imaging planes of the heart, defined by specific structures that they demonstrate. In the following discussion, typical surface anatomical locations are described for the cardiac windows, but these are subject to significant individual variation based on the location and lie of the heart. The emergency physician should focus on identifying the key features of the primary cardiac views, regardless of the window where the probe needs to be positioned to obtain

them. As with other EUS the heart is scanned in real-time through all tissue planes.

1. Subcostal four-chamber view or subxiphoid view
This view is obtained by placing the probe just under the rib cage or xiphoid process with the transducer directed towards the patient's left shoulder and the probe marker directed towards the patient's right (9-o'clock). The liver is used as a sonographic window. The heart lies immediately behind the sternum, so that it is necessary, in a supine patient, to direct the probe in a plane that is almost parallel with the horizontal plane of the stretcher. This requires firm downward pressure, especially in patients with a protuberant abdomen. Structures imaged in the subcostal four-chamber view include the right atrium, tricuspid valve, right ventricle, left atrium and left ventricle. The pericardial spaces should be examined both anterior and posterior to the heart. By scanning inferiorly, the inferior vena cava may also be visualized as it drains into the right atrium. This can help with orientation, as well as giving information about the patient's preload and intravascular volume status.
2. Parasternal long axis view
This view is typically obtained using the third, fourth, and fifth intercostal spaces, immediately to the left of the patient's sternum. Structures imaged on this view include the pericardial spaces (anterior and posterior), the right ventricle, the septum, the left

atrium and left ventricular inflow tract, the left ventricle in long axis, the left ventricular outflow tract, the aortic valve, and the aortic root.

The probe marker is directed to the patient's left hip (approximately 4-o'clock). In this view the aortic outflow and left atrium will be on the right side of the screen as it is viewed and the cardiac apex will be on the left side of the screen.

Alternately, the probe may be directed to the patient's *right* shoulder (approximately 10-o'clock). This will provide a view that is reversed 180 degrees from that seen in cardiology texts, but is consistent with orientation in the rest of emergency ultrasound, with the apex (a leftward structure) on the right side of the screen as it is viewed. In this probe position the orientation will appear very similar to the subcostal view, only slightly higher so that the aortic outflow tract is seen instead of the right atrium.

3. Parasternal short axis view
This view is obtained by rotating the probe 90 degrees clockwise from the parasternal long axis, so that the marker is directed in an approximately 8-o'clock direction. By rocking the probe in these interspaces, images can be obtained from the apex of the left ventricle inferiorly up to the aortic root superiorly. Intervening structures which can be identified, all in cross-section, include the entire left ventricular cavity, the right ventricle, the papillary

muscles, the mitral valve, the aortic outflow tract, the aortic valve, the aortic root and the left atrium. The view at and immediately below the mitral valve may be particularly helpful for determining overall left ventricular systolic function.

4. Apical four-chamber view
This view is obtained by placing the probe at the point of maximal impulse (PMI) as determined by physical exam. Normally this is in the fifth intercostal space and inferior to the nipple, however this location is subject to great individual variation. The probe is directed up along the axis of the heart toward the right shoulder, with the marker oriented towards the patient's right or 9-o'clock, which is towards the ceiling in a supine patient. The apex of the heart is at the center of the image with the septum coursing vertically also in the center of the screen. The left ventricle and left atrium will be on the right side of the screen, and the right ventricle and atrium will be on the left side of the screen. This view demonstrates both the mitral and tricuspid valves and gives a clear view of the relative volumes of the two ventricular cavities, the motions of their free walls, and the interventricular septum.

iv. Secondary cardiac views

1. Subxiphoid short axis view
This view is obtained by placing the probe in the same location as the subxiphoid four-chamber view, but rotating the probe marker 90 degrees clockwise into a cephalad direction at 12-o'clock. This provides a short axis view of

the right and left ventricles. With side to side rocking motion, a longitudinal view of the inferior vena cava draining into the right atrium can be seen. This view is the preferred subxiphoid view for many trauma surgeons in the evaluation of blunt truncal trauma.

2. Venous windows

The inferior vena cava (IVC) may be traced by following hepatic veins in a subcostal window.

Comparing the maximal IVC diameter in exhalation with the minimal IVC diameter in inhalation may provide a qualitative estimate of preload. Collapse of 50 - 99% is normal; complete collapse may indicate volume depletion and <50% collapse may indicate volume overload, pericardial tamponade and/or right ventricular failure. Additionally, an estimation of preload may be obtained by measuring the height of the meniscus sonographically in the internal jugular from the sternal notch and adding 5 cm.

3. Suprasternal notch view

This view is obtained by placing the probe in the suprasternal notch, directed inferiorly into the mediastinum. The marker is usually directed obliquely between the patient's right and anterior since this is the plane followed by the aortic arch as it crosses from right anterior to left posterior of the mediastinum. A bolster under the patient's shoulders with the neck in full extension will facilitate this view used to visualize the aortic arch and great vessels.

4. Apical two chamber view

This view is obtained by rotating the probe clockwise 90 degrees from the apical four chamber view, so that the probe marker is directed in a cephalad direction or 12-o'clock. This allows visualization of the anterior and inferior left ventricular walls as well as the mitral and aortic valves. This view is infrequently utilized in the cardiac EUS.

v. Relationship of the cardiac views

Several of the cardiac views provide images of the same planes of the heart from different angles. This is true of the following pairs of views: the parasternal long axis and apical two-chamber views; the apical four-chamber and sub-xiphoid four-chamber views; and the parasternal short axis and the subxiphoid short axis views.

c. Key components of the cardiac EUS evaluation

i. Evaluation of pericardial effusion.

Pericardial effusion usually images as an anechoic or hypoechoic fluid collection within the pericardial space. With inflammatory, infectious, malignant or hemorrhagic etiologies this fluid may have a more complex echogenicity and not appear anechoic or uniform. Fluid tends to collect dependently, but may be seen in any portion of the pericardium. Very small amounts of pericardial fluid can be considered physiologic and are seen in normal individuals. A widely used system classifies effusions as none, small (< 10 mm in diastole, often non-circumferential), moderate (circumferential, no part greater than 10 mm in width in diastole), large (10-20 mm in width), and very large (>20

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- mm and/or evidence of tamponade physiology).
 - ii. Echocardiographic evidence of tamponade. Diastolic collapse of any chamber in the presence of moderate or large effusion is indicative of tamponade. Hemodynamic instability with a moderate or large pericardial effusion, even without identifiable diastolic collapse, is suspicious for tamponade physiology.
 - iii. Evaluation of gross cardiac motion in the setting of cardiopulmonary resuscitation. Terminal cardiac dysfunction typically progresses through global ventricular hypokinesis, incomplete systolic valve closure, absence of valve motion, absence of ventricular motion, finally culminating in intracardiac gel-like densities. The lack of mechanical cardiac activity, or true cardiac standstill, demonstrated by EUS has the gravest of prognoses. The decision to terminate resuscitative efforts should be made on clinical grounds in conjunction with the sonographic findings.
 - iv. Evaluation of global cardiac function. Published investigations demonstrate that emergency physicians with relatively limited training and experience can accurately estimate cardiac ejection fraction. Left ventricular systolic function is typically graded as normal (EF>50%), moderately depressed (EF 30-50%), or severely depressed (EF<30%).
5. Documentation
EUS of the heart are interpreted by the treating physician as they are performed and are used to guide contemporaneous clinical decisions. Such interpretations should be documented in the medical record as a dictated, hand-written, or templated note. Documentation should include the indication for the procedure, a description of the organs or structures studied and an interpretation of the findings. Whenever feasible images should be stored as a part of the medical record and done so in accordance with facility policy requirements. Given the often emergent nature of such ultrasound examinations the timely delivery of care should not be delayed by the archiving of ultrasound images.
6. Equipment Specifications
A phased array cardiac transducer is optimal, since it facilitates scanning through the narrow intercostal windows, and is capable of high frame rates which provide better resolution of rapidly moving cardiac structures. If this is not available a 2-5 MHz general-purpose curved array abdominal probe, preferably with a small foot-print, will suffice. The cardiac presets available on most equipment may be activated to optimize cardiac images. Doppler capability may be helpful in certain extended emergency echo indications but is not routinely used for the primary cardiac EUS indications. Both portable and cart-based ultrasound machines may be used, depending on the location and setting of the examination.
7. Quality Control and Improvements, Safety, Infection Control and Patient Education
Policies and procedures related to quality, safety, infection control and patient education should be developed in accordance with specialty or organizational guidelines. Specific institutional guidelines may be developed to correspond with such guidelines.
- Pelvic Ultrasound**
1. Introduction
The American College of Emergency Physicians (ACEP) has developed these criteria to assist practitioners performing emergency ultrasound studies (EUS) of the pelvis in emergency patients to evaluate for evidence of acute pathology including ectopic

pregnancy, ovarian cysts and tubo-ovarian abscess.

First trimester pregnancy complications such as abdominal pain and vaginal bleeding are common presenting complaints in the emergency department. Ultrasound finding of a clear intrauterine pregnancy, in many instances, minimizes the possibility of ectopic pregnancy and can decrease ED throughput time and decrease morbidity. The scope of practice for pelvic ultrasound in ED will vary depending on individual experience, comfort/skill level and departmental policies. However, some centers may chose to evaluate the ovaries and seek to identify tubo-ovarian abscess, fibroids, and pelvic masses.

EUS of the pelvis occurs as a component of the overall clinical examination of a patient presenting with symptoms related to the pelvic area. It is a clinical focused examination, which, in conjunction with historical and laboratory information, provides additional data for decision-making. It attempts to answers specific questions about a particular patient's condition. Other diagnostic tests may provide more detailed information than EUS, show greater anatomic detail, or identify alternative diagnoses. However, EUS is non-invasive, rapidly deployed, allows the patient to remain in the ED, and avoids delays, costs, specialized technical personnel, and bio-hazardous potentials of radiation and contrast agents. These advantages make it a valuable addition to the diagnostic resources available to the emergency physician caring for patients with time-sensitive or emergency conditions such as ectopic pregnancy and other causes of acute pelvic pain.

2. Indications/Limitations:

- a. Primary
 - i. To evaluate for the presence of intrauterine pregnancy, minimizing the likelihood of an ectopic pregnancy

when modifying factors such as infertility treatment are not present.

- b. Extended
 - i. Ovarian cysts
 - ii. Fibroids
 - iii. Tobu-ovarian abscess
 - iv. Ruling out ovarian torsion by ruling out cyst or mass
 - v. Identifying suspected ectopic pregnancy
- c. Limitations
 - i. Infertility patients or other with specifically known risk factors for heterotopic pregnancy.
 - ii. Assessing pelvic sonographic anatomy after vaginal-rectal surgery
 - iii. Evaluation of fetal health outside of fetal heart rate determination
- d. Pitfalls
 - i. Ovarian torsion evaluation in the presence of ovarian, para-ovarian, tubal or para-tubal mass
 - ii. Ovarian mass evaluation for presence of malignancy versus benign mass
 - iii. Interstitial pregnancy
 - iv. Presence of ovarian torsion due to a mass or cyst in first trimester patient with identified intrauterine pregnancy

3. Qualifications and Responsibilities of the Performing Medical Professional

Pelvic EUS provides information that is the basis of immediate decisions concerning further evaluation, management, and therapeutic interventions. Because of the direct bearing on patient care, the rendering of a diagnosis by EUS represents the practice of medicine, and therefore is the responsibility of the supervising physician.

Due to the time-critical and dynamic nature of ectopic pregnancy and other pathologic conditions of the pelvis, emergency interventions may be mandated by the diagnostic findings of the EUS of the pelvis.

For this reason, EUS of the pelvis should occur as soon as the clinical decision is made that the patient needs a sonographic evaluation.

Physicians of a variety of medical specialties may perform EUS of the pelvis. Training should be in accordance with specialty or organizational specific guidelines. Physicians should render a diagnostic interpretation in a time frame consistent with the management of acute presentations related to the pelvic area, as outlined above.

4. Specifications for the performance and interpretation of EUS of the pelvis

a. General – Organs and structures evaluated by pelvic EUS are scanned systematically in real time through all tissue planes in at least two orthogonal directions. The primary focus of the pelvic EUS is the identification on an intrauterine pregnancy. Pelvic sonographic evaluations for other pelvic pathology, as described in “Extended Indications”, are performed based on the clinical situation and appropriate emergency physician’s sonographic experience.

b. Technique

i. Identification

1. Uterus. The uterus should be examined in at least two planes, the short and long axis, to avoid missing important findings that may lie off of the center or endometrial canal, such as in an interstitial pregnancy or fibroids. The uterus should be traced from the fundus to the cervix, confirming that it is actually the uterus that is being scanned rather than a gestational reaction from a large ectopic pregnancy. Fibroids, which can cause significant pain and even bleeding, should be noted. A pregnancy that is with in

5 to 7 mm (exact minimum normal distance varies from reference to reference) from the edge of the myometrium is concerning for being an interstitial ectopic pregnancy.

2. Cul-de-sac. The cul-de-sac or pouch of Douglas may contain a small to moderate amount of fluid in the healthy female pelvis depending on her point in the menstrual cycle. Large amounts of fluid are abnormal but may not be tied to significant pathology. When an ectopic pregnancy is of concern, a significant amount of fluid in the pouch of Douglas raises the concern for rupture. Echogenic fluid in the pelvis may be consistent with either pus or blood.
3. Ovaries. The ovaries should also be scanned in at least two planes, short and long axis, completely through each of the paired organs. This should provide a good view of possible masses next to an ovary as well as cysts located on the periphery of an ovary. In the first trimester patient with pain evaluating the ovaries may identify an unexpected cause for pain despite having an intrauterine pregnancy. For instance ovarian masses or cysts that may in themselves cause pain or have led to torsion of the ovary.
4. Fallopian tubes. The normal fallopian tube can be visualized as it originates from the cornua of the uterus. Visualization can be limited by significant bowel gas or enhanced when distended by fluid such as in hydrosalpinx or tubo-ovarian abscess.

ii. Real-time scanning technique

1. Overview. The pelvic ultrasound examination can be performed at the patient's bedside and when possible, immediately following the pelvic examination portion of the physical examination to limit the time a patient spends in the lithotomy position. A chaperone should also be present for all endovaginal examinations. In most instances, the transabdominal portion of the ultrasound exam should precede the transvaginal component as information regarding bladder fullness, position of the uterus, and anatomic variations can be appreciated. As well, in a certain percentage of patients, an intrauterine pregnancy will be documented, thereby minimizing the need to perform the endovaginal ultrasound exam.
2. Transabdominal. The patient lies supine on the examination table. The transducer is placed on the lower abdomen just above the symphysis pubis and the pelvic organs are examined through a window of the distended bladder. Bladder filling is ideal when the bladder dome is just above the uterine fundus. Underdistention limits visualization. Images are obtained in sagittal and transverse planes. To optimally image the uterus, the transducer is aligned with the long axis of the uterus, which is often angled right or left of the midline cervix. The ovaries and adnexa are best seen by sliding the transducer to the contralateral side and angling back toward the ovary of interest. The transabdominal technique provides the best overview of the pelvis.
3. Transvaginal. For the transvaginal examination, the best imaging is achieved with an empty bladder. Two possible patient positions will facilitate endovaginal scanning. In the first, the patient is supine on a stretcher or bed with her legs flexed. Folded sheets or pads are placed under her buttocks to elevate her pelvis above the examination table to allow room for transducer manipulation. Alternatively, the patient may be examined on a pelvic examination table with her feet in stirrups. The probe may be placed in the vagina by the patient or the examiner. The uterus is examined entirely in two planes. When in the sagittal plane, the examiner sweeps the transducer laterally to sides to visualize the uterus in its entirety, because it is often deviated to one side. The transducer is then rotated 90 degrees counterclockwise to obtain a coronal view. The transducer can then be angled anteriorly, posteriorly, and to each side to obtain a full assessment of the uterus.

After the sagittal and coronal planes of the uterus have been fully interrogated, other structures in the pelvis can be visualized, such as the cul-de-sac, fallopian tubes, and ovaries. The cul-de-sac is inferior to the uterus and the ovaries are located lateral to the uterus and usually lie anterior to the internal iliac veins and medial to the external iliac vessels.

5. Documentation

EUS of the pelvis are interpreted by the treating physician as they are performed and are used to guide contemporaneous clinical decisions. Such interpretations should be documented in the medical record as a dictated, hand-written, or templated note. Documentation should include the indication for the procedure, a description of the organs or structures studied and an interpretation of the findings. Whenever feasible, images should be stored as part of the medical record and done so in accordance with facility policy requirements. Given the often emergent nature of such ultrasound examinations, the timely delivery of care should not be delayed by the archiving of ultrasound images.

6. Equipment specifications

A curved linear array abdominal transducer with a range of approximately 3 to 5 MHz as well as an endovaginal transducer with an approximate range of 4 to 8 MHz is used for pelvic EUS. Color or power Doppler and pulsed wave Doppler are critical if an assessment of blood flow will be made. Both portable and cart-based ultrasound machines may be used, depending on the location and setting of the examination. There is no indication to interrogate the fetus with pulsed wave Doppler, consequently high energy ultrasound use should be avoided. Further, all pelvic ultrasound studies should be kept to a reasonably limited amount of time when sensitive tissue such as the fetus is involved.

7. Quality Control and Improvements, Safety, Infection Control, and Patient Educations and Concerns

Policies and procedures related to quality, safety, infection control, and patient education should be developed in accordance with specialty or organizational guidelines. Specific institutional guidelines may be developed to correspond with such guidelines.

Renal

1. Introduction

The American College of Emergency Physicians (ACEP) has developed these criteria to assist practitioners performing emergency ultrasound studies (EUS) of the kidneys and bladder in patients suspected of having diseases involving the urinary tract.

Emergency ultrasound of the kidneys and urinary tract may identify both normal and pathological conditions. The primary indications for this application of EUS are in the evaluation of obstructive uropathy and acute urinary retention. The evaluation of perirenal structures and the peritoneum for perirenal fluid is considered in the criteria for Trauma EUS.

EUS of the kidneys and urinary tract occurs as a component of the overall clinical evaluation of a patient with possible urinary tract disease. It is a clinically focused examination, which, in conjunction with historical and laboratory information, provides additional data for decision-making. It attempts to answer specific questions about a particular patient's condition. While other tests may provide information that is more detailed than EUS, have greater anatomic specificity, or identifies alternative diagnoses, EUS is non-invasive, is rapidly deployed and does not entail removal of the patient from the resuscitation area. Further, EUS avoids the delays, costs, specialized technical personnel, the administration of contrast agents and the biohazardous potential of radiation. These advantages make EUS a valuable addition to available diagnostic resources in the care of patients with time-sensitive or emergency conditions such as acute renal colic and urinary retention.

2. Indications/Limitations

a. Primary

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- i. The rapid evaluation of the urinary tract for sonographic evidence of obstructive uropathy and/or urinary retention in a patient with clinical findings suggestive of these diseases.
 - b. Extended
 - i. Causes of obstructive uropathy
 - ii. Causes of acute hematuria
 - iii. Causes of acute renal failure
 - iv. Infections and abscesses of the kidneys
 - v. Renal cysts and masses
 - vi. Gross bladder and prostate abnormalities
 - vii. Renal trauma
 - c. Contraindications: No absolute contraindications exist. Contraindications are relative, based on specific features of the patient's clinical condition.
 - d. Limitations
 - i. EUS of the kidney and urinary tract is a single component of the overall and ongoing evaluation. Since it is a focused examination EUS does not identify all abnormalities or diseases of the urinary tract. EUS, like other tests, does not replace clinical judgment and should be interpreted in the context of the entire clinical picture. If the findings of the EUS are equivocal additional diagnostic testing may be indicated.
 - ii. Examination of the kidneys and collecting system may be technically limited by:
 - 1. Patient habitus including obesity, paucity of subcutaneous fat, narrow intercostal spaces
 - 2. Bowel gas
 - 3. Abdominal or rib tenderness
 - 4. An empty bladder
 - e. Pitfalls
 - i. When bowel gas or other technical factors prevent a complete real-time scan through all tissue planes, the limitations of the examination should be identified and documented. As is customary in emergency practice, such limitations may mandate further evaluation by alternative methods, as clinically indicated.
 - ii. Hydronephrosis may be mimicked by several normal and abnormal conditions including dilated renal vasculature, renal sinus cysts, and bladder distension. Medullary pyramids may mimic hydronephrosis, especially in young patients.
 - iii. Presence of obstruction may be masked by dehydration.
 - iv. Absence of hydronephrosis does not rule out a ureteral stone. Many ureteral stones, especially small ones, do not cause hydronephrosis.
 - v. Patients with an acutely symptomatic abdominal aortic aneurysm may present with symptoms suggestive of acute renal colic.
 - vi. Both kidneys should be imaged in order to identify the presence of either unilateral kidney or bilateral disease processes.
 - vii. The bladder should be imaged as part of EUS of the kidney and urinary tract. Many indications of this EUS exam are caused by conditions identifiable in the bladder.
 - viii. Variations of renal anatomy are not uncommon and may be mistaken for pathologic conditions. These include reduplicated collection systems, unilateral, bipartite, ectopic and horse-shoe kidney.
 - ix. Renal stones smaller than 3 mm are usually not identified by current sonographic equipment. Renal stones of all sizes may be missed and are usually identified by the shadowing they cause as their echogenicity is

similar to that of surrounding renal sinus fat.

3. Qualifications and Responsibilities in the performance and interpretation of EUS of the renal system.

EUS of the kidneys and urinary tract provides information upon which immediate decisions for further evaluation, management and interventions are based. Rendering a diagnosis by EUS impacts patient care directly and qualifies as the practice of medicine.

Therefore, performing and interpreting EUS is the responsibility of the supervising physician.

Due to the time-critical and dynamic nature of many conditions of renal pathology, emergency interventions may be undertaken based upon findings of the EUS exam. For this reason, EUS should occur as soon as the clinical decision is made that the patient needs a sonographic exam.

Physicians of a variety of medical specialties may perform renal ultrasound examinations. Training should be in accordance with specialty or organization specific guidelines. Physicians should render a diagnostic interpretation in a time frame consistent with the management of acute renal pathology, as outlined above.

4. Specifications for EUS of the kidneys and urinary tract

a. General. An attempt should be made to image both kidneys and the bladder in patients with suspected renal tract pathology undergoing EUS. In addition, hydronephrosis and urinary retention are frequently unsuspected causes of abdominal pain and may be recognized in the course of other abdominal or retroperitoneal EUS examinations.

b. Technique

i. Identification. The kidneys are more easily identified in their longitudinal

axis. They are paired structures that lie oblique to every anatomic plane and at different levels on each side. Their inferior poles are anterior and lateral to their superior poles. Both hila are also directed obliquely. Orientation is defined with respect to the axes of the organ of interest (longitudinal, transverse, and oblique), rather than standardized anatomic planes (sagittal, coronal, oblique and transverse). The long axis of the kidney approximates the intercostal spaces and longitudinal scans may be facilitated by placing the transducer plane parallel to the intercostal space. By convention the probe indicator is always toward the head or the vertebral end of the rib on both the right and left sides.

Transverse views of the kidneys are therefore usually also transverse to the ribs, resulting in prominent rib shadows that may make visualizing the kidneys more difficult unless a small footprint or phased array probe is available. Transverse views are obtained on both sides by rotating the probe 90 degrees counter-clockwise from the plane of the longitudinal axis.

ii. Real-time scanning technique

1. Overview. The kidneys are retroperitoneal in location and are usually above the costal margin of the flanks in the region of the costovertebral angle. A general-purpose curved array abdominal probe with a frequency range of between 2-5 MHz is generally used. A small footprint or phased array probe may facilitate scanning between the ribs, but may require several windows in the longitudinal plane if the kidney is long, or superficial. Images of both kidneys should be

obtained in the longitudinal and transverse planes for purposes of comparison and to exclude absence of either kidney. The bladder should be imaged to assess for volume, evidence of distal ureteral obstruction and for calculi. As with other EUS, the organs of interest are scanned in real-time through all tissue planes in at least two orthogonal directions.

2. Details of technique. The right kidney may be visualized with an anterior subcostal approach using the liver as a sonographic window. Imaging may be facilitated by having the patient in the left lateral decubitus position or prone. Asking the patient to take and hold a deep breath may serve to extend the liver window so that it includes the inferior pole of the kidney. Despite these techniques, parts or the entire kidney may not be seen in this view due to interposed loops of bowel, in which case the kidney should be imaged using an intercostal approach in the right flank between the anterior axillary line and midline posteriorly. For this approach the patient can be placed in the decubitus position with a bolster under the lower side with the arm of the upper side fully abducted, thus spreading the intercostal spaces. Separate views of the superior and inferior poles are often required to adequately image the entire kidney in its longitudinal plane. To obtain transverse images, the transducer is rotated 90 ° counter-clockwise from the longitudinal plane. Once in the transverse plane, the

transducer can be moved superiorly and medially, or inferiorly and laterally to locate the renal hilum. Images cephalad to the hilum represent the superior pole and those caudad represent the inferior pole. The left kidney lacks the hepatic window, necessitating an intercostal approach similar to the one described above for the right flank.

The bladder is imaged from top to bottom and from side to side, in transverse and sagittal planes, respectively. While a full bladder facilitates bladder scanning, distension may be a cause of artifactual hydronephrosis and is therefore to be avoided in scanning the kidneys. Ideally the bladder is scanned prior to voiding (and again post-void, if outlet obstruction is a consideration), and kidney scanning performed after voiding. Such ideal conditions are rarely met with the exigencies of EUS and emergency care.

3. Key components of the examination. The kidneys should be studied for abnormalities of the renal sinus and parenchyma. Under normal circumstances, the renal collecting system contains no urine, so that the renal sinus is a homogeneously hyperechoic structure. A distended bladder can cause mild hydronephrosis in normal healthy adults. Several classifications of hydronephrosis have been suggested. One that is easily applied and widely utilized is Mild or Grade I (any hydronephrosis up to Grade II),

Moderate or Grade II (the calices are confluent resulting in a “bear’s paw” appearance), or Severe or Grade III (the hydronephrosis is sufficiently extensive to cause effacement of the renal parenchyma). Other abnormalities identified including cysts, masses and bladder abnormalities may require additional diagnostic evaluation. Measurements may be made of the dimensions of abnormal findings and the length and width of the kidneys. Such measurements are rarely relevant in the focused EUS examination.

5. Documentation

EUS of the kidneys and urinary tract are interpreted by the treating physician as they are performed and are used to guide contemporaneous clinical decisions. Such interpretations should be documented in the medical record as a dictated, hand-written, or templated note. Documentation should include the indication for the procedure, a description of the organs or structures studied and an interpretation of the findings. Whenever feasible images should be stored as a part of the medical record and done so in accordance with facility policy requirements. Given the often emergent nature of such ultrasound examinations the timely delivery of care should not be delayed by the archiving of ultrasound images.

6. Equipment Specifications

A general purpose curved array abdominal transducer with a frequency range of between 2-5 MHz is generally used. A small footprint or phased array probe may facilitate scanning between the ribs. A higher frequency 5.0-7.0 MHz transducer may give better resolution in children and smaller adults. Both portable and cart-based ultrasound machines may be used, depending upon the location of the patient and the setting of the examination.

7. Quality Control and Improvements, Safety, Infection Control and Patient Education
Policies and procedures related to quality, safety, infection control and patient education should be developed in accordance with specialty or organizational guidelines. Specific institutional guidelines may be developed to correspond with such guidelines.

Trauma

1. Introduction

The American College of Emergency Physicians (ACEP) has developed these criteria to assist practitioners who are performing emergency ultrasound studies (EUS) of the torso of the injured patient and commonly referred to as the Focused Assessment by Sonography in Trauma (FAST) exam.

Trauma ultrasound is used to evaluate the peritoneal, pericardial or pleural spaces in anatomically dependent areas by combining several separate focused ultrasound examinations of the chest, heart, abdomen and pelvis. Since a variety of formats and content have been advocated for the FAST exam, and because this document considers some applications of trauma ultrasonography that are beyond the scope of the FAST, this document will refer to such examinations as “Emergency Ultrasound (EUS) in Trauma,” or “Trauma EUS.”

The primary indication for this application is in the identification of pathologic free fluid released from injured organs or structures. Trauma EUS is performed at the bedside to assess for hemopericardium, hemothorax, hemoperitoneum or other abnormal fluids such as urine or bile. Free fluid is a marker of injury, not the injury itself. Since certain important traumatic conditions such as hollow viscus injury, mesenteric vascular injury, diaphragmatic rupture may cause minimal

hemorrhage, they can be easily overlooked by trauma EUS. Trauma EUS also may not differentiate between different types of pathological fluid such as urine and blood. These characteristics of trauma EUS have implications for management of patients in whom these injuries are a consideration.

Trauma EUS is performed as an integral component of trauma resuscitation. Other diagnostic or therapeutic interventions may take precedence or may proceed simultaneously with the EUS evaluation. It is a clinically focused examination, which, in conjunction with historical and laboratory information, provides additional data for decision-making. It attempts to answer specific questions about a particular patient's condition. While other tests may provide information that is more detailed than EUS, have greater anatomic specificity, or identifies alternative diagnoses, EUS is non-invasive, is rapidly deployed and does not entail removal of the patient from the resuscitation area. Further, EUS avoids the delays, costs, specialized technical personnel, the administration of contrast agents and the biohazardous potential of radiation. These advantages make EUS a valuable addition to available diagnostic resources in the care of patients with time-sensitive or emergency conditions such as acute thoracic and abdominal trauma.

Trauma EUS is well suited to mass casualty situations where it can be used to rapidly triage multiple victims. It can be performed on the patient with spinal immobilization and with portable equipment, allowing it to be used in remote or difficult clinical situations such as aeromedical transport, wilderness rescue, expeditions, battlefield settings, and space flight. Finally, serial trauma EUS exams can be repeated as frequently as is clinically indicated. These advantages make it a valuable addition to diagnostic resources available in the care of patients with the time-sensitive

and/or emergent conditions associated with torso trauma.

2. Indications/Limitations

- a. Primary
 - i. To rapidly evaluate the torso for evidence of traumatic free fluid suggestive of injury in the peritoneal, pericardial, and pleural cavities.
- b. Extended
 - i. Pneumothorax
 - ii. Solid organ injury
 - iii. Triage of multiple or mass casualties
- c. Contraindications
 - i. There are no absolute contraindications to trauma EUS. There may be relative contraindications based on specific features of the patient's clinical situation, e.g. extensive abdominal or chest wall trauma.
 - ii. The need for immediate laparotomy is often considered a contraindication to trauma EUS; however, even in this circumstance, EUS evaluation for pericardial tamponade or pneumothorax may be indicated prior to transfer to the operating room.
- d. Limitations
 - i. Trauma EUS is a single component of the overall and ongoing resuscitation. Since it is a focused examination EUS does not identify all abnormalities resulting from truncal trauma. EUS, like other tests, does not replace clinical judgment and should be interpreted in the context of the entire clinical picture. If the findings of the EUS are equivocal additional diagnostic testing may be indicated.
 - ii. EUS in trauma is technically limited by
 1. Bowel gas
 2. Obesity

-
- 3. Subcutaneous emphysema
 - iii. Trauma EUS is likely to be less accurate in the following settings
 - 1. Pediatric patients
 - 2. Patients with other reasons for free fluid such as prior diagnostic peritoneal lavage, ascites, ruptured ovarian cyst, pelvic inflammatory processes
 - e. Pitfalls
 - i. When bowel gas or other technical factors prevent a complete or adequate exam, these limitations should be identified and documented. As usual in emergency practice, such limitations may mandate further evaluation by alternative methods, as clinically indicated.
 - ii. Most studies show that peritoneal free fluid is not identified by EUS until at least 500 ml is present. Thus, a negative exam does not preclude early or slowly bleeding injuries.
 - iii. Some injuries may not give rise to free fluid and may therefore easily be missed by trauma EUS. These include contained solid organ injuries, mesenteric vascular injuries, hollow viscus injuries, and diaphragmatic injuries.
 - iv. Non-traumatic fluid collections such as ascites, or pleural and pericardial effusions, which are due to antecedent medical conditions, may be mistakenly ascribed to trauma. Credible history and associated clinical findings, as well as the sonographic features of the free fluid may suggest such conditions.
 - v. Trauma EUS does not specifically identify most solid organ injuries.
 - vi. EUS does not identify retroperitoneal hemorrhage.
 - vii. A negative trauma EUS is not accurate in excluding intra-abdominal injury after isolated penetrating trauma.
 - viii. Blood clots form rapidly in the peritoneum. Clotted blood has sonographic qualities similar to soft tissue, and may be overlooked.
 - ix. Perinephric fat may be mistaken for hemoperitoneum.
 - x. Fluid in the stomach or bowel may be mistaken for hemoperitoneum.
 - xi. Small hemothoraces may be missed in the supine position.
 - xii. In the evaluation of the pericardium, epicardial fat pads, pericardial cysts, and the descending aorta have been mistaken for free fluid.
 - xiii. Patients with peritoneal or pleural adhesions with significant hemorrhage may not develop free fluid in the normal locations.
 - xiv. In the suprapubic view, posterior acoustic enhancement caused by the bladder can result in pelvic free fluid being overlooked. Gain settings should be adjusted accordingly.
3. Qualifications and Responsibilities in the performance and interpretation of Trauma EUS
- Trauma EUS provides information that is the basis of immediate decisions about further evaluation, management, and therapeutic interventions. Because of its direct bearing on patient care, the rendering of a diagnosis by trauma ultrasound represents the practice of medicine, and therefore is the responsibility of the supervising physician.
- Due to the time-critical and dynamic nature of traumatic injury, emergent interventions may be mandated by the diagnostic findings of EUS examination. For this reason, trauma EUS should be performed as soon as possible (usually minutes) following the decision that the patient needs a sonographic evaluation.
- Physicians of a variety of medical specialties may perform the FAST examination. Training

should be in accordance with specialty or organization specific guidelines. Physicians should render a diagnostic interpretation in a time frame consistent with the management of acute traumatic injury, as outlined above.

4. Specifications for performance and interpretation of EUS in trauma

a. General Trauma EUS is performed simultaneously with other aspects of resuscitation. The transducer is placed systematically in each of 4 general regions with known windows to the peritoneum, pericardium and pleural spaces for detection of fluid and other sonographic abnormalities. The precise location of these regions varies from patient to patient, and is only used as a means to the real goal of identifying specific potential spaces where pathological collections of free fluid are known to collect. The transducer is placed in each of the regions consecutively and then tilted, rocked and rotated to allow for real-time imaging of the underlying potential space(s). The ultrasound images obtained are interpreted in real-time as the exam is being performed. If possible, images may be retained for purposes of documentation, quality assurance, or teaching.

b. Technique

i. Overview. The trauma EUS exam evaluates 4 general regions or “views” for free fluid in defined potential spaces. The order in which the regions are examined may be determined by clinical factors such as the mechanism of injury or external evidence of trauma. Since scientific investigations have shown that the single most likely site for free fluid to be identified is the right upper quadrant, many practitioners start with this view, and then progress in a clockwise rotation through the sub-xiphoid, left upper

quadrant, and suprapubic views. As with other EUS, the potential spaces being examined should be scanned methodically in real-time through all tissue planes. If possible, they should be evaluated in at least two orthogonal directions. Identification of the potential spaces in a single still image or plane is likely to result in early injuries, or those with small volumes of free fluid, being overlooked.

ii. Real-time scanning technique

1. The right flank. Also known as the perihepatic view, Morison’s pouch view or right upper quadrant view. Four potential spaces for the accumulation of free fluid are examined in this region (listed in a cephalad to caudad direction): the pleural space, the subphrenic space, the hepatorenal space (Morison’s pouch), and the inferior pole of the kidney, which is a continuation of the right paracolic gutter.

In this region, the liver usually provides a sonographic window for all four potential spaces. If the liver margin is sufficiently low, the probe can be placed in a subcostal location in the mid-clavicular line. Cooperative patients may facilitate this by being asked to “take a deep breath and hold” while the four potential spaces are examined. In the majority of patients the liver does not afford an adequate window with a subcostal probe position, so an intercostal approach is necessary. In order to minimize rib shadowing, the transducer should be placed in an intercostal space in a location between the mid-clavicular and posterior

axillary lines, with the plane of the probe parallel with the ribs. This plane is about 45 degrees counter-clockwise from the long axis of the patient's body. The probe indicator, by convention, is always directed toward the head (the vertebral end) of the rib. By angling the probe superiorly, the subhepatic space and the right pleural space may be visualized for fluid. Abnormal fluid collections in the pleural space are visualized as anechoic or hypoechoic collections above the diaphragm.

Angling inferiorly allows visualization of Morison's pouch and may show the inferior pole of the right kidney. In many patients, bowel gas is interposed between the liver and the inferior pole of the kidney, necessitating a more posterior approach to visualize this space.

Gain settings should be adjusted so that the diaphragm and renal sinus fat appear white, and known hypoechoic structures (such as the inferior vena cava, GB, or renal vein) appear black.

2. The pericardial view. Also known as the subcostal or subxiphoid view. To examine the pericardium, the liver in the epigastric region is most commonly used as a sonographic window to the heart. The heart lies immediately behind the sternum, so that it is necessary, in a supine patient, to direct the probe in a direction toward the left shoulder that is almost parallel with the horizontal plane of the

stretcher. This requires firm downward pressure, especially in patients with a protuberant abdomen, in order to obtain a view posterior to the sternum ("under" the sternum) in the supine patient. Both sagittal and transverse planes may be used. Many find the transverse plane easier, especially in obese patients, since it requires slightly less compression of the abdominal wall to obtain adequate views. The potential space of the pericardial sac is examined for fluid both inferiorly (between the diaphragmatic surface and the inferior myocardium) and posteriorly. Slight angulation in a caudal direction when the probe is held in a transverse orientation allows visualization of the IVC and hepatic veins including their normal respiratory variability. In some patients, a subxiphoid view is not possible due to anterior abdominal trauma, or body habitus. In this case, other routinely used cardiac windows such as the parasternal or apical four-chamber views may be used. These are described in the Guideline to Cardiac EUS.

3. Left flank. In this view, also known as the perisplenic or left upper quadrant view, four potential spaces are sonographically explored, analogous to the right upper quadrant view. These four spaces are: the pleural space, the subphrenic space, the splenorenal space, and the inferior pole of the kidney, which is a continuation of the left paracolic gutter. This view can make some use of the spleen

as a sonographic window, but, being so much smaller, it provides a much more limited window than the liver on the right. For this reason the posterior intercostal approach described for the right upper quadrant is utilized extensively in the left upper quadrant. In order to avoid the gas filled splenic flexure and descending colon it is usually necessary to place the probe on the posterior axillary line or even more posteriorly. As is the case on the right side, the probe indicator, by convention, is always directed toward the head (the vertebral end) of the rib. This requires that, on the left, the probe is rotated approximately 45 degrees clockwise from the long axis of the patient's body. Angulation superiorly allows visualization of the left pleural space. As on the right, the pleural spaces are investigated for evidence of hemothorax by looking for anechoic or hypoechoic collections above the diaphragm. In order to visualize the inferior pole of the left kidney and the superior extent of the left paracolic gutter, it is usually necessary to move the probe one to three rib spaces in a caudal direction. In each rib space, the probe is systematically swept through all planes in a search for free fluid.

4. Pelvic. Also known as the suprapubic view, retrovesical, and rectovesical view (in the male), and the retrouterine, rectouterine, and pouch of Douglas view (in the female). This space is the most dependent peritoneal space in the

supine position. A full bladder is ideal to visualize the potential spaces in the pelvis, but adequate views can often be obtained with a partly filled bladder. When the bladder is empty, large volumes of anechoic or hypoechoic free fluid may still be seen, however it is not possible to reliably rule out the presence of smaller amounts of free fluid. The probe is placed in the transverse plane immediately cephalad to the pubic bone. This maximizes the sonographic window afforded by the bladder. The probe is rocked from inferior to the dome of the bladder in a systematic manner through all tissue planes. The probe may be rotated 90 degrees counter-clockwise into the sagittal plane for additional visualization of the bladder and pelvic peritoneum.

Gain settings usually need to be decreased in this view to account for the posterior acoustic enhancement caused by the fluid-filled bladder.

iii. Additional windows

1. Paracolic gutters. These potential spaces are anatomically continuous with the hepatorenal and splenorenal spaces. Windows inferior to the level of kidneys and next to the iliac crests may reveal bowel surrounded by fluid.
2. Anterior pleural. In non-collapsed lung, the anterior visceral and parietal pleura are intimately apposed, and slide past one another during respiration. Absence of identifiable pleural sliding is indicative of separation of the parietal-visceral pleural interface by interposed gas, i.e.

pneumothorax. In the supine position, the anterior pleura are examined by placing the probe in a sagittal plane in the rib interspaces between the clavicle and diaphragm. The approximate midclavicular line is used on both sides. It is necessary to adjust frequency, depth, focus and gain settings to optimally image these superficial structures.

iv. Other considerations

Trendelenburg and sitting position may increase the sensitivity of the ultrasound exam for abnormal fluid in the right upper quadrant and pelvis, respectively. Serial trauma EUS may be performed in response to changes in the patient's condition, to check for the development of previously undetectable volumes of free fluid or for purposes of ongoing monitoring, as indicated clinically.

5. Documentation

Trauma ultrasounds are interpreted by the treating physician as they are performed and are used to guide contemporaneous clinical decisions. Such interpretations should be documented in the medical record as a dictated, hand-written, or templated note. Documentation should include the indication for the procedure, a description of the organs or structures studied and an interpretation of the findings. Whenever feasible, images should be stored as a part of the medical record and done so in accordance with facility policy requirements. Given the often emergent nature of such ultrasound examinations the timely delivery of care should not be delayed by the archiving of ultrasound images.

6. Equipment Specifications

Generally, a curvilinear abdominal or phased array cardiac ultrasound probe at frequencies of 2.0-5 MHz with a mean of 3.5 MHz will be used for an adult and 5.0 MHz for children

and smaller adults. A small footprint may facilitate scanning between the ribs. A depth of field of up to 25 cm may be required in order to adequately visualize deeper structures in the right upper quadrant in large patients. Both portable and cart-based ultrasound machines may be used, depending on the location and setting of the examination.

7. Quality Control and Improvements, Safety, Infection Control and Patient Education

Policies and procedures related to quality, safety, infection control and patient education should be developed in accordance with specialty or organizational guidelines. Specific institutional guidelines may be developed to correspond with such guidelines.

Ultrasound-Guided Procedures

1. Introduction

The American College of Emergency Physicians (ACEP) has developed these criteria to assist to practitioners utilizing emergency ultrasound (EUS) to facilitate the performance of procedures in the emergency patient.

Ultrasound has been shown to be helpful in determining patency of vascular structures and with the placement of central lines as well as peripheral lines. The Agency for HealthCare Research and Quality highlighted ultrasound guided central lines as a key intervention that should be implemented immediately into twenty-first century patient care. This focus on patient safety will promote procedural ultrasound as it enables trained operators toward a "one stick" standard. These ultrasound examinations are performed at the bedside to identify vascular anatomy and guide direct visualization and cannulation of vessels.

Additional procedural uses include ultrasound to assess for potential abscess formation and to drain fluid collections that accumulate

pathologically in various potential spaces. Confirming fracture reduction and endotracheal tube placement, assessing bladder volume and directing aspiration, as well as facilitating lumbar puncture or pacemaker placement are other potential uses of procedural ultrasound.

The advantages of procedural ultrasound includes, improved patient safety, decreased procedural attempts, and decreased time to perform many procedures in patients whom the technique would otherwise be difficult. It is important to recognize that procedural ultrasound is a method to identify relevant anatomy and pathology before proceeding with invasive procedures while aiding the accurate execution and minimizing procedural complications. Procedural ultrasound is an adjunct to emergency care.

2. Indications/Limitations

a. Primary

i. Vascular access

1. To identify central venous structures, their relative location and their patency in facilitating placement of central venous catheters.
2. To identify peripheral venous structures, their relative location and patency in facilitating placement of peripheral venous access.
3. To identify arterial structures, their relative location and flow characteristics in facilitating placement of arterial lines.

b. Extended

- i. To evaluate for and/or drain with ultrasound guidance or localization:
 1. soft tissue abscess
 2. peritonsillar abscess
 3. pericardial effusion (pericardiocentesis)
 4. pleural effusion (thoracentesis)

5. peritoneal fluid (paracentesis)
6. joint effusion (arthrocentesis)
7. cerebrospinal fluid (lumbar puncture)

ii. To evaluate for and localize with ultrasound:

1. soft tissue foreign bodies
2. pacemaker placement and capture
3. fracture reduction
4. endotracheal tube placement

c. Limitations

- i. Procedural ultrasound is an adjunct to care. No modality is absolutely accurate. Procedural ultrasound should be interpreted and utilized in the context of the entire clinical picture.
- ii. Procedural ultrasound may be technically limited by:
 1. obese habitus
 2. subcutaneous air

d. Pitfalls

- i. Needle localization and its associated artifact must be visualized before proceeding with any procedure. The short axis transverse approach allows only a cross section of the needle to be visualized by the ultrasound beam and may lead to errors in depth perception of the needle. The long axis orientation allows the operator to trace the entire path and angle of the needle from the entry site at the skin and is preferred when this transducer orientation is possible.
- ii. It is important to identify a vessel by multiple means before attempting cannulation. The difference between veins and arteries can be determined by compressibility (veins compress), shape (arteries tend to be circular in transverse view, with muscular walls) and flow dynamics if Doppler is available and/or utilized.

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- iii. Many times abnormal structures can be compared to adjacent tissue or to the other normal side. If questions persist about the sonographic appearance of a structure, another imaging modality may be warranted.
3. Qualifications and Responsibilities of the Performing Medical Professional
Physicians of a variety of medical specialties may perform procedural ultrasound. Training should be in accordance with specialty or organization specific guidelines.
 4. Specifications for Individual Examinations
 - a. General – Ultrasound can be used to both localize the relevant anatomy and pathology before executing the procedure in a sterile manner, or with sterile probe covers and real-time assessment. All invasive procedures should employ standard sterile techniques to diminish the risk of infection. A high frequency ultrasound probe is placed over the anatomy of interest in both a sagittal and transverse plane. The probe should be initially placed at the primary window and then be tilted, rocked and rotated to allow for real-time imaging of the area(s) involved. This may take more time with difficult windows, challenging patients or other patient priorities. Interpretation should be done at the bedside immediately with performance of the real-time examination.
 - b. Procedural ultrasound techniques-
Ultrasound guidance or ultrasound assisted procedures can be performed using either of two accepted techniques:
 - i. Static: Anatomic structures are identified and an insertion position is identified with ultrasound. The procedure then proceeds as it would without ultrasound and is not performed with the transducer imaging the patient through key components of the procedure.
 - ii. Real-Time: The ultrasound transducer is placed in a sterile covering and the key components of the procedure are performed with simultaneous ultrasound visualization during the procedure (e.g. using ultrasound to visualize a needle entering a vessel)
 - c. Procedural ultrasound examinations
 - i. Internal jugular vein
 - ii. Femoral vein
 - iii. Subclavian vein
 - iv. External jugular vein
 - v. Brachial and cephalic veins
 - vi. Arterial cannulation
 - d. Additional Procedures
 - i. Soft tissue abscess drainage
 - ii. Peritonsillar abscess drainage
 - iii. Pericardiocentesis
 - iv. Pleurocentesis
 - v. Paracentesis.
 - vi. Arthrocentesis
 - vii. Lumbar puncture
 - viii. Fracture reduction
 - ix. Endotracheal tube confirmation
 - x. Bladder volume assessment-suprapubic aspiration
 5. Documentation
Procedural ultrasound requires documentation of the ultrasound assisted procedure either as a dictated, hand-written, or templated note. Documentation should include the indication for the procedure, a description of the organs or structures identified and an interpretation of the findings. Whenever feasible, images should be stored as a part of the medical record and in accordance with facility policy requirements. Given the often emergent nature of such ultrasound procedures, the timely delivery of care should not be delayed by the archiving of ultrasound images.
 6. Equipment Specifications
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Multiple probes can be used yet high frequency (7.0-12 MHz) linear array transducers work best to image superficial and vascular structures. Microconvex endoluminal probes can be used to identify abscess formation in areas such as the oropharynx. Portable and cart-based ultrasound machines may be used, depending on the location and setting of the examination.

7. Quality Control and Improvements, Safety, Infection Control and Patient Education
Policies and procedures related to quality, safety, infection control and patient education should be developed in accordance with specialty or organizational guidelines. Specific institutional guidelines may be developed to correspond with such guidelines.

Venous Thrombosis

1. Introduction

The American College of Emergency Physicians (ACEP) has developed these criteria to assist practitioners performing emergency ultrasound studies (EUS) of the venous system in the evaluation of venous thrombosis.

The primary application of venous EUS is in evaluation of deep venous thrombosis (DVT) of the proximal lower extremities. Lower extremity venous EUS differs in two fundamental aspects from the “Duplex” evaluation performed in a vascular laboratory. First, its anatomic focus is limited to two specific regions of the proximal deep venous system. Second, its sonographic technique consists primarily of dynamic evaluation of venous compressibility in real time. This approach to lower extremity proximal venous EUS is often referred to as “limited compression ultrasonography” (LCU). Since B-mode (gray-scale) equipment is widely available, and because substantial scientific evidence supports the use of limited compression ultrasonography, this guideline is

focused on the evaluation of proximal lower extremity DVT using this technique. It is recognized that many emergency physicians have access to equipment with color flow and Doppler capabilities, and are experienced in its use. It is likely that they will augment their venous EUS with this technology.

Lower extremity venous EUS is performed and interpreted in the context of the entire clinical picture. It is a clinically focused examination, which, in conjunction with historical and laboratory information, provides additional data for decision-making. It attempts to answer specific questions about a particular patient’s condition. EUS of the lower extremities does not identify all abnormalities or diseases of the deep venous system. If the findings of lower extremity venous EUS exam are equivocal, further imaging or testing may be needed.

2. Indications/Limitations

- a. Primary
 - i. Evaluation for acute proximal DVT in the lower extremities.
- b. Extended
 - i. Chronic DVT
 - ii. Distal DVT
 - iii. Superficial venous thrombosis
 - iv. Diagnosis of other causes of lower extremity pain and swelling under consideration in the evaluation of DVT such as cellulitis, abscess, muscle hematoma, fasciitis, Baker’s cyst
 - v. Upper extremity venous thrombosis
- c. Contraindications
 - i. Known, acute proximal DVT. If an ultrasound examination would not have any bearing on clinical decision-making, it should not be performed.
 - ii. Other contraindications are relative, based on specific features of the patient’s clinical condition.

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- d. Limitations
- i. EUS of the lower extremity deep venous system is a single component of the overall and ongoing evaluation. Since it is a focused examination EUS does not identify all abnormalities or diseases of the lower extremity veins. EUS, like other tests, does not replace clinical judgment and should be interpreted in the context of the entire clinical picture. If the findings of the EUS are equivocal additional diagnostic testing may be indicated.
 - ii. A prior history of DVT may limit the utility of LCU. The chronic effects of DVT are highly variable in extent, location, timing and morphology. A completely normal venous EUS exam is likely to exclude both acute and chronic DVT. However, the interpretation of abnormal findings in patients with a history of prior DVT may be outside the scope of a lower extremity venous EUS examination.
 - iii. Examination can be limited by:
 - 1. Obesity
 - 2. Local factors such as tenderness, sores, open wounds, or injuries
 - 3. The patient's ability to cooperate with the exam
- e. Pitfalls
- i. A non-compressible vein may be mistaken for an artery, leading to a false negative result.
 - ii. An artery may be mistaken for a non-compressible vein, leading to a false positive result.
 - iii. Large superficial veins may be mistaken for deep veins. This pitfall is more likely in obese patients and those with occlusive DVT causing distension in the collateral superficial veins. Depending on the compressibility of the vein, this can lead to both false positive and false negative results.
- iv. While thrombus may be directly visualized on examination, it is frequently isoechoic to unclotted blood and failure to see echogenic clot should not be used to exclude the diagnosis of DVT.
 - v. Inguinal lymphadenopathy may be mistaken for a non-compressible common femoral vein.
 - vi. Failure to arrange for repeat venous evaluation in patients with suspicion for isolated calf or distal DVT.
 - vii. Failure to consider the possibility of iliac or inferior vena cava obstruction as a cause for LE pain or swelling. While color flow and Doppler techniques may identify the presence of these conditions, they are beyond the usual scope of the EUS exam.
 - viii. A negative scan for a lower extremity DVT does not rule out the presence of pulmonary embolism.
 - ix. Not recognizing that the superficial femoral vein is part of the deep venous system. This sometimes confusing terminology has resulted in some authorities referring to the superficial femoral vein as simply the femoral vein.
3. Qualifications and Responsibilities of the Performing Medical Professional
- Limited compression ultrasound of the venous system provides information that is the basis of immediate decisions concerning the patient's evaluation, management, and therapy. Because of its direct bearing on patient care, the rendering of a diagnosis by venous EUS represents the practice of medicine, and therefore is the responsibility of the supervising physician.
- Due to the potential for life-threatening complications arising from acute DVT,

emergent interventions may be mandated by the diagnostic findings of the EUS exam. For this reason, EUS exam should occur as soon as the clinical decision is made that the patient needs a sonographic evaluation.

Physicians of a variety of medical specialties may perform a lower extremity limited compression exam. Training should be in accordance with specialty or organization specific guidelines. Physicians should render a diagnostic interpretation in a time frame consistent with the management of acute DVT, as outlined above.

4. Specifications for Individual Examinations

a. General Emergency ultrasound for the diagnosis of DVT evaluates for compressibility of the lower extremity deep venous system with specific attention directed towards the common femoral and popliteal veins.

b. Technique

i. Identification of veins. For the purposes of lower extremity EUS, the proximal deep veins of the lower extremity are those in which thrombus poses a significant risk of pulmonary embolization. These include the common femoral, superficial femoral, and popliteal veins. It is important to note that the superficial femoral vein is part of the deep system, not the superficial system as the name suggests. Conversely the deep femoral (profunda femoris) vein is not considered to be a source of embolizing thrombi, and is therefore not included in the evaluation for DVT.

In the distal leg, the popliteal vein is formed by the confluence of the anterior and posterior tibial veins with the peroneal vein approximately 4-8

cm distal to the popliteal crease.

Continuing proximally, the popliteal vein becomes the superficial femoral vein as it passes through the adductor canal approximately 8-12 cm proximal to the popliteal crease. The superficial femoral vein joins the deep femoral vein to form the common femoral vein approximately 5-7 cm below the inguinal ligament. Prior to passing under the inguinal ligament to form the external iliac vein, the common femoral is joined by the great saphenous vein (a superficial vein) merging from the medial thigh. In relation to the companion arteries, the popliteal vein is superficial to the artery. The common femoral vein lies medial to the artery only in the region immediately inferior to the inguinal ligament. The vein abruptly runs posterior to the artery distal to the inguinal region.

ii. Compression. The sonographic evaluation is performed by compressing the vein directly under the transducer while watching for complete apposition of the anterior and posterior walls. If complete compression is not attained with sufficient pressure to cause arterial deformation, obstructing thrombus is likely to be present.

iii. Patient positioning. To facilitate the identification of the veins and test for compression, they need to be distended. This is accomplished by placing the lower extremities in a position of dependency preferably by placing the patient on a flat stretcher in reverse Trendelenberg. If the patient is on a gurney where this is not possible, the patient should be placed semi-sitting with 30 degrees of hip flexion.

iv. Transducer. A linear array vascular probe with a frequency of 6 – 10 MHz and width of 6 – 8 cm is often ideal. Narrower transducers may make it harder to localize the veins and to apply uniform compression. For larger patients, a lower frequency or even an abdominal probe will facilitate greater tissue penetration.

v. Real-time scanning technique.

1. The common femoral vein. Gel is applied to the groin and medial thigh for a distance about 10 centimeters distal to the inguinal crease. Filling of the common femoral vein might be augmented by placing a small bolster under the knee resulting in slight (about 10 degrees) hip flexion. Mild external rotation of the hip (30 degrees) may also be helpful. The vein and artery may have almost any relationship with one another, although the vein is frequently seen posterior to the artery. Distinction of the two vessels may therefore depend on size (the vein is usually larger), shape (the vein is more ovoid) and compressibility. If color-flow or Doppler is utilized characteristic signatures can help with differentiation.

Compressive evaluation of the vessel commences at the highest view obtainable at the inguinal ligament. Angling superiorly, a short section of the distal common iliac vein might be scanned. Systematic scanning, applying compression every centimeter, should be continued to the bifurcation of the common femoral vein into its superficial

and deep branches and 1 – 2 cm beyond, since branch points are particularly susceptible to thrombosis. If difficulty is encountered in following the common femoral vein to the bifurcation, or in clearly identifying the two branching vessels, techniques to optimize the angle of interrogation should be used. In equivocal cases, comparison with the contralateral side may be helpful.

2. The popliteal vein. The patient can be placed in either a prone or decubitus position. In the latter case, the knee is flexed 10 – 30 degrees, and the side of the leg being examined should be down. If the patient is prone, placing a bolster under the ankle to flex the knee to about 15 degrees facilitates filling of the popliteal vein. Again reverse Trendelenberg positioning promotes venous filling. Gel is applied from about 12 centimeters superior, to 5 centimeters inferior to the popliteal crease. The vein usually lies superficial to the artery. Both vessels lie superficial to the bony structures, which can be used as landmarks to anticipate the depth of the vessels. If difficulty is encountered in identifying the terminal branches of the popliteal vein, it is possible that the patient has one of the common variants of venous anatomy. In the absence of clear anatomic identification of the termination of the popliteal vein, the major venous structures should be imaged to approximately 7 centimeters below the popliteal crease. In equivocal cases, comparison with

the contralateral side may be helpful.

- vi. Additional components of the exam.
 1. The superficial femoral vein. As noted previously, this vein is not a primary focus of the standard lower extremity EUS evaluation. In cases where there is a high suspicion of DVT and an otherwise normal exam of the common femoral and popliteal veins, the superficial femoral vein may also be evaluated.
 2. Color flow and Doppler. Color flow and Doppler assessment may be used to localize the vessels, although the use of this technology is beyond the scope of the standard EUS exam.
 - vii. Gray scale identification of clot. While thrombus may be hyperechoic, and thus directly visualized on exam, it is also frequently isoechoic to unclotted blood. Consequently, failure to see echogenic clot should not be used to exclude the diagnosis of DVT.
5. Documentation

In performing venous EUS, images are interpreted by the treating physician as they are acquired and are used to guide contemporaneous clinical decisions. Image documentation should be incorporated into the medical record as a dictated, hand-written, or templated note. Documentation should include the indication for the procedure, the views obtained, a description of the structures studied and an interpretation of the findings. Limitations of the exam, and impediments to performing a complete exam should be noted. The written report of the venous EUS should document the presence of complete, partial or absent collapse in each vein examined. Whenever feasible, images should be stored as a part of the medical record and done so in
 6. Equipment Specifications

A linear array vascular probe with a frequency of 6 – 10 MHz and width of 6 – 8 cm is often ideal. Narrower transducers may make it harder to localize the veins and to apply uniform compression. For larger patients, a lower frequency or even an abdominal probe will facilitate greater tissue penetration. Color or power Doppler capabilities may be of assistance in localizing venous structures. Both portable and cart-based ultrasound machines may be used, depending on the location and setting of the examination.
 7. Quality Control and Improvements, Safety, Infection Control and Patient Education

Policies and procedures related to quality, safety, infection control and patient education should be developed in accordance with specialty or organizational guidelines. Specific institutional guidelines may be developed to correspond with such guidelines.